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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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Direct Reading Frost Gage Is Reliable, Inexpensive

ABSTRACT. — A tube-type gage is economical, easy to make, and is a reliable indicator of frost depth. Gage readings were within ± 5 centimeters of indicated true frost depth 95 percent of the time.
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In our search for a better way of measuring soil frost depth, we tested two kinds of direct-reading, tube-type gages during the winter of 1968-69. The gages were a modified Gandahl gage (hereafter called MGT gage) [1] developed at the U. S. Army Cold Regions Research and Engineering Laboratory and a similar gage developed at the Fernow Experimental Forest. [2]

The MGT gage consists of an inner polyethylene tube, 5/8 inch inside diameter by 3/4 inch outside diameter, and an outer polyethylene tube, 1 inch inside diameter by 1-1/4 inch outside diameter. The bottoms of both tubes are either heat sealed or closed with a commercially available plug. The inner tube is filled with 0.01 percent solution of fluorescein and then with medium-size clean sand. The fluorescein dye solution produces a sharp color differentiation between the frozen and liquid phase. The sand adds rigidity to the polyethylene tube, decreases expansion upon freezing of the solution, and prevents thermal overturn. The top is sealed in the same manner as the bottom. A wire loop is embedded in the top of the inner tube so that it can be pulled out of the ground when the gage is installed. Materials to fabricate a complete 2-meter gage cost approximately $2.00.

The gage is installed in a 3.28-centimeter (1-1/4-inch) hole. The outer tube should extend above the ground to a height greater than expected snow depth. Even in areas of shallow snow, it should extend about 1 meter (3.3 feet) above the ground for convenience in reading the gage. The outer tube is capped with a commercially available snap-on or slip-on cap. Upon installation, the ground surface level is marked on the inner tube to indicate a zero-depth reading. The inner tube can be pulled from inside the outer tube by a dowel with a hook on one end. The frost depth is read from a calibrated adhesive tape applied to the inner tube or by a calibrated stick.

The Fernow gage is similar except that the outer housing is made from copper tubing and a Kool-aid solution is used for color differentiation upon freezing. The gage is approximately 75 centimeters (2-1/2 feet) long and 1.25 centimeters (1/2 inch) in diameter.

Gages were installed on both a flat Plainfield sand site and a southeast sloping Fayette silt loam site. Readings were made over a 4-month period with snow being removed several times to allow for deeper frost penetration. Gage readings were compared with penetrometer readings, which give an accurate measure of bonded frost depth. [3]

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[1] *Brown, Jerry, and Richard, Warren. A modified freeze-thaw depth indicator. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Tech. Note. 1968.*

[2] *Patric, James H., and Fridley, Burley D. A device for measuring soil frost. U.S.D.A. Forest Serv. Res. Note NE-94. Northeast. Forest Exp. Sta., Upper Darby, Pa.*

[3] *Sartz, Richard S. A test of three indirect methods of measuring depth of frost. Soil Sci. 104: 273- 278. 1966.*

Both the MGT gages and the Fernow gages performed well. However, the Fernow gages varied considerably during the critical measurement periods of fast freezing and thawing, apparently because of heat conduction (fig. 1). Color differentiation between the frozen and unfrozen phases was usually sharp and clear for both gage types. However, during periods of rapid freezing and thawing the color separation lines in the MGT gages were sometimes diffused and mixed.

The MGT gages read within ±5 centimeters of the penetrometer readings 95 percent of the time. Average mean difference for all plots was ± 2.3 centimeters, with an average standard deviation of 1.96 centimeters. The Fernow gages read within ± 5 centimeters of the penetrometer readings only 65 percent of the time. Average mean difference for all plots was ±4.8 centimeters with an average standard deviation of 3.56 centimeters. The larger variance in the Fernow gage readings resulted when they were exposed to the weather and when the frost depth was shallow (fig. 1). However, when covered with snow or when the frost was deep, they performed as well as the MGT gages.

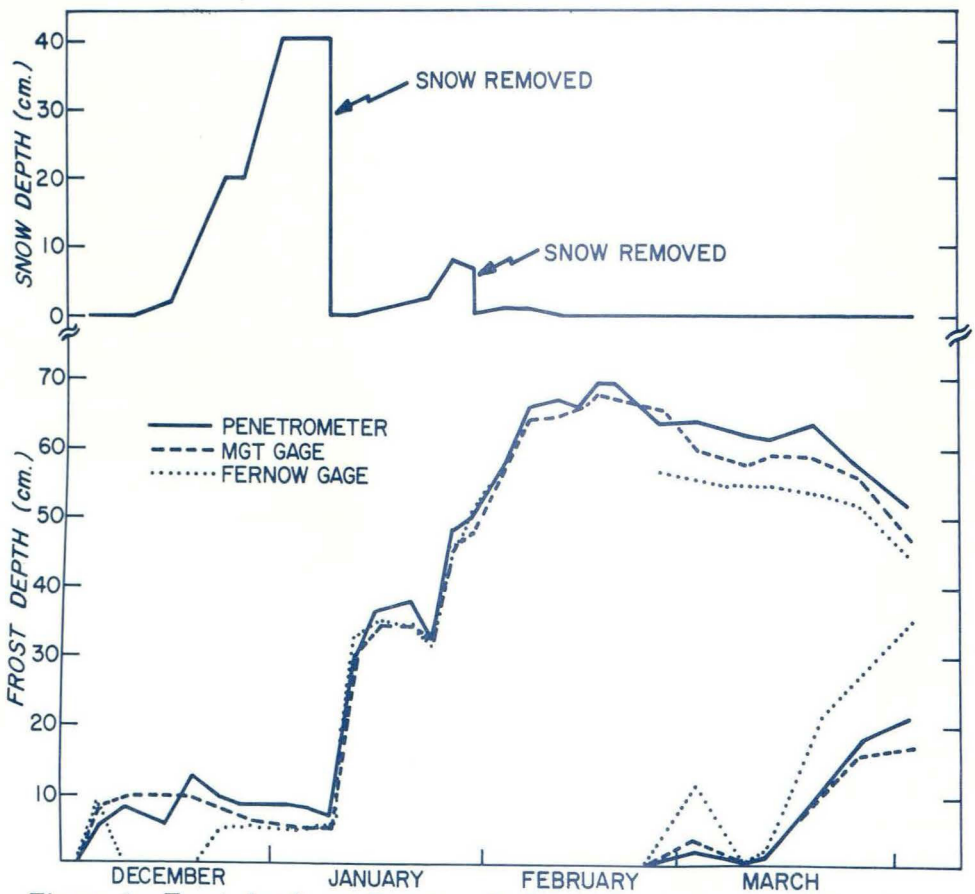

Figure 1.—Frost depth on Fayette silt loam site as measured by the penetrometer, MGT gage, and Fernow gage. Fernow gage measured frost only to a depth of 60 cm. Lines in lower right corner of graph show thawing from the surface down.

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